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(54) IMPROVED PROCESS FOR MANUFACTURE OF AMYLOPECTIN-BASED FOOD PRODUCTS

(71) We, NATIONAL STARCH AND CHEMICAL CORPORATION, a corporation organised under the laws of the State of Delaware, United States of America, having an office at 750 Third Avenue, New York, New York 10017, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

It is highly desirable that ready-to-eat food products based upon farinaceous materials possess certain properties of texture, taste, and ease of manufacture. Thus, for example, such products should be produced by a process which permits their rapid solidification or setting, thereby enabling them to retain the shape in which they were initially prepared. They should have sufficient strength and rigidity to permit their being sliced or cut, if such an operation is required. Upon being put into edible form, such products should be crisp and should retain their crispiness over prolonged periods. They should not be unpleasantly tough and, of course, they should have an appealing flavor. Where frying of these food products is required, the absorption of excess quantities of oil during the frying step should be avoided and variations in the amount of oil absorbed should be reduced to a minimum. Color variations should also be reduced to a minimum, while the shelf life of the products should be the maximum which is attainable.

Present recipes and means of production provide few, if any, special measures which are designed to insure the attainment of the above described properties of appearance, texture and taste. Thus, such prior art products have not set rapidly, have not retained their desired shapes and have proved somewhat difficult to handle and cut. Furthermore, the taste of such prior art products has fluctuated as a result of the inherent variations present in the various natural base ingredients which have been used in their manufacture. The taste of such products has also necessarily

reflected the flavor imparted by the cereal flour, notably corn flour, which is ordinarily utilized therein, thereby severely limiting the variability in taste and texture which the practitioner desires in making a variety of such ready-to-eat specialty food products.

The present invention provides a process for the preparation of a food product which comprises the steps of: (1) moistening a composition comprising an amylopectin product (as hereinafter defined), said composition containing less than 5% by weight of amylose; (2) subjecting the moistened composition to simultaneous heat, pressure and mixing action in order to effect the gelatinization and hydration of said amylopectin product; (3) shaping the moistened composition which results from step 2; and (4) cooking the moistened composition and thereby obtaining an edible product characterized by its light-texture and crispiness; said cooking procedure being conducted at a point in time simultaneous with or subsequent to step 3.

We have found that when amylopectin is used as the base component of the food products of this invention, many advantages are realized. Thus, such products rapidly set immediately upon their emergence from the apparatus utilized in their manufacture. The latter factor increases the shape retention qualities of these products and results in firm products which can better withstand further treatments such as cutting, drying and frying. Furthermore, these products exhibit prolonged storage stability, limited oil absorption upon frying and controlled texture and taste characteristics. Prior to this invention, for example, as set forth in U.S. Patent 3,407,070, it was thought that it was absolutely essential to utilize high amylose starch or amylose as a significant part of the farinaceous component in the preparation of food products of the type described herein. Thus, the use of amylopectin in significant quantities was thought to result in blends which were difficult to extrude and shape because of the gummy texture and poor set of the uncooked mass. Moreover, sub-

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sequent to being cooked, such amylopectin-containing food products were thought to be fragile and to lack crispiness. It is therefore, surprising and unexpected that when amylopectin is employed preferably under specified conditions of moisture content, pressure and temperature set forth in this disclosure, that there should, in fact, result easily workable products possessing superior shaping and extrusion characteristics which yield edible light-textured crisp and tasty food products.

As an example of the wide variety of specialty food products which may thus be prepared by means of the process of this invention, one may list crackers, chips, cereal puffs, and other so-called snack items; the latter products being available in a multiplicity of flavors and shapes.

It is well known that starch is ordinarily composed of two fractions, one a branched fraction known as amylopectin, and the other a linear fraction known as amylose. Each starch type contains these two fractions in a specific ratio characteristic of that particular starch. Methods for separating starch into these two components are known. Furthermore, some starches have been genetically developed which are characterized by a large preponderance of the one fraction or the other.

When we use the term "amylopectin product" herein and in the appended claims we refer to (a) amylopectin resulting from the fractionation of whole starch into its respective amylose and amylopectin components, or (b) whole starches, such as waxy maize, waxy sorghum, and waxy rice starches, which are composed substantially entirely of amylopectin, or (c) amylopectin as mentioned under (a) or whole starches as mentioned under (b) but (i) further treated easy with heat and/or acids or with oxidizing agents to form so-called thin boiling products or (ii) chemically cross-linked or inhibited or derivatized, as by means of an esterification reaction which would thus yield amylopectin esters such, for example, as the acetate, propionate, and butyrate esters; or, by means of an etherification reaction which would thus yield amylopectin ethers such, for example, as the hydroxyethyl, hydroxypropyl, or carboxymethyl ethers.

According to a preferred embodiment of our process, one or more of the above defined amylopectin products, together with any desired additives, such as shortening, flavors, and colors, in the presence of from 5 to 20% of added moisture, based on the total weight of the moisturized composition, is blended and the resulting mixture is passed through an apparatus, preferably a heated extruder, which is capable of subjecting the mixture to a simultaneous combination of mixing, along with sufficient heat and pressure to gelatinize and hydrate the amylopectin product and to force the resulting mass through the shaping

orifice as a solid formed, shape-retaining, food product.

Depending upon the particular process conditions which are utilized, the resulting product, as obtained from the shaping step, may be in its ultimate edible form or it may merely need an additional cooking operation in order to be put into such final form.

Whenever the description of the process of this invention relates to the specific use, therein, of an extruder, it is to be understood that any other type of apparatus capable of functioning in a similar manner is also applicable for use in preparing the products of this invention.

In a variation of the process, the amylopectin product may, if desired, be admixed with one or more fillers, including, for example, flour or meal derived from various cereal grains such as wheat and corn. Thus, the flour or meal filler can be admixed with the required amylopectin in a concentration up to 50% of the total weight of the solids within the moisturized composition, i.e. the moisturized composition comprising the resulting blend of water, required amylopectin product and filler, which is ultimately passed through the extruder.

The term "filler" is used herein and in the appended claims to mean whole and comminuted edible tubers and whole or cracked cereal grains as well as flours and meals derived from the latter. The whole cereal grains may, in turn, be pre-cooked or pretreated in order to obtain fast cooking products. Typical procedures for achieving such fast cooking products include passing an aqueous slurry of the grain over heated drums at temperatures which simultaneously gelatinize and dry it, or, the use of a chemical treatment.

In addition to the latter fillers or, as the sole additive, we may also introduce an amylose containing material, provided however, that the total amylose content of the composition to be moistened is less than 5% of the total weight of the solids within the final moisturized composition including the amylose containing additive as well as any other fillers which may be present. The term "amylose-containing material" is used herein and in the appended claims to mean amylose and high amylose starches (i.e. starches which contain at least 50% by weight of amylose, as well as starches which contain both amylose and amylopectin in their normal proportions).

The concentration of the amylopectin product in the moistened product should preferably be selected so as to insure a total amylopectin concentration of from 50 to 92% of the total weight of the moisturized composition. The total amylopectin concentration refers to the total weight of the amylopectin content of the amylopectin product along with the weight of the amylopectin which may be

present in any high amylose starches or other amylose containing material that may be optionally utilized as part of the final blend.

The moisture levels for our uncooked food products, which may range from 5 to 20% by weight, are particularly suitable in most instances for permitting the immediate cooking or frying of the food product subsequent to its shaping so as to readily produce an edible product. Thus, by reducing the concentration of moisture to a level of about 15% or less it is possible to eliminate the need for an intermediate drying step. However, even where higher concentrations of moisture in the range of about 16% or more are utilized, only a minimal drying period is necessary. In contrast, prior art procedures ordinarily incorporate higher concentrations of moisture in the uncooked farinaceous mass and thereby require a time-consuming, intermediate drying of the shaped mass prior to its being cooked or fried. In this respect see U.S. Patents 3,027,258 and 3,407,070, wherein the use of higher moisture contents are required and, as a result, a rather lengthy intermediate drying step is necessary prior to the final cooking operation. It is, therefore, a distinct advantage of the present process that when low moisture levels are utilized therein, no intermediate drying step is required after the shaping operation and prior to the final cooking or frying of the thus-shaped mass.

The initial dry blend may, if desired, contain a wide variety of additives which serve, for example, to flavor, color, emulsify and stabilize the resulting amylopectin-based food products. Among such extraneous additives are included: flavoring materials such as dried cheese, dried fruits, nuts, pizza flavor, onion, garlic, sodium chloride, monosodium glutamate, sweeteners, pepper and paprika; coloring agents such as carotene; stabilizers and thickeners such as methyl cellulose and sodium caseinate; preservatives such as calcium propionate; plasticizers; shortening; emulsifiers; and antioxidants. It is to be noted that these additives may be present in our food products in only minor concentrations which usually do not exceed 10%, based on the total weight of the dry ingredients. Although such additives are generally added to the initial dry blend, some may, if desired, be injected therein as the mass passes through the cooled section of the extruder barrel or die.

The amount of moisture in the extrusion mixture should be sufficient to gelatinize and hydrate the amylopectin under the particular extrusion conditions employed, taking into account the specific amylopectin product being used, the nature and proportions of the other ingredients, the temperature and pressure employed in the extrusion operation and the particular characteristics which are desired in the ultimate food product. Thus, concentrations of water ranging from 5 to 20%, and

preferably, 10 to 14%, based on the total weight of the composition, are ordinarily used. It should be noted that the moisture which may be inherently present in the various components of the composition is not included in determining the amount of water which is to be added to the dry blend. The addition of water is usually accomplished by spraying, i.e. mixing the dry materials while spraying them with water. Where it is not desired to initially add the entire concentration of water to the mixture, the balance may be injected, as steam or as hot water, directly into the extruder.

The resulting mixture, which may be in the form of a dry or damp powder or a viscous suspension, may be slightly preheated, if desired, although such heating is unnecessary in view of the fact that this process is solely dependent upon the exertion of relatively high heat in the extruder barrel in order to hydrate and swell the amylopectin product. The moistened blend is then fed into the extruder by a pump, ram, screw, double motion ribbon blender, or by any other suitable means.

For the extrusion step, one may employ any device capable of subjecting the moisturized blend to a mixing action and to the heat and pressure necessary to gelatinize and hydrate the amylopectin product, while simultaneously applying the pressure necessary to force the mixture through an orifice, or multiplicity of orifices, at the terminal end of the apparatus. Although we may thus use a batch type pressure cooker or a continuous type pressure conveyor-cooker in conjunction with a roller or similar shaping device, it is preferable to use an extruder which is capable of conducting all of the required operations in a single continuous procedure. The extruder is typically fitted with a cooking section whose temperature is capable of being regulated, a cooling system which is capable of reducing the temperature to below 212°F., and an orifice or die which gives the product its final shape. A wide variety of orifice shapes may be used including, for example, straight or serrated slits, round or oval openings, fluted circular shapes and annular openings. It is also possible to extrude the product in the form of a ribbon or a thin sheet so that the desired shape of the individual pieces of the ultimate food product may be cut from the resulting ribbons and sheets.

The extruder may also be arranged so that the first section of its barrel contains heating elements which induce hydration and gelatinization of the amylopectin product, whereas the second section of the extruder barrel may be water-cooled so as to be able to remove a considerable amount of heat from the gelatinized mixture. Another variation consists in using two or more extruders in tandem, one to heat the other to cool. In either instance, the combined heat, pressure and mixing action serve to effectively homogenize the mixture in

spite of the relatively low amounts of moisture which are present.

The temperature applied within the extruder barrel will depend upon the amount and type of amylopectin product present in the mixture as well as on the moisture content thereof. In order to realize the most favorable taste and color characteristics in the finished food product, the temperature should be as low as possible, consistent with the need to hydrate the amylopectin product. Thus, typical barrel temperatures range from 200°F. to 350°F.

The temperature of the extruder die will, in most instances, be kept within the range of from 100°F. to 212°F., it being necessary to lower the temperature of the material in the extruder to below 212°F. in order to avoid the escape of steam, i.e., to avoid flashing. The precise temperature within the above cited range that may be used is also directly related to the composition of the extruded mixture. As will be described hereinafter, the reduction in temperatures between the barrel and the die may be omitted where it is desired to utilize the flashing phenomenon in order to put the product into its final expanded form without the need for a subsequent cooking operation.

The pressure utilized within the extrusion mechanism will vary with the type of extruder, the compression ratio and speed of the screw employed, the nature of the material being extruded, the construction of the die, the temperature being used and the amount of water present. Typical pressures thus range from 10 to 5000 psig. (pounds per square inch, gauge) depending on whether the extruder utilizes a transport or a compression auger or combination.

The necessity for allowing the resulting food product to set upon the conclusion of the extrusion operation is primarily dependent upon the concentration of water and the type and concentration of amylopectin product which is present in the food product as well as on the degree of cooling which is applied. Under optimum conditions, the end product will be extruded as a non-tacky, shape-retaining mass which can be immediately cut at high speeds and which, on further cooling, will increase in rigidity. The ability to produce products displaying immediate shape-retaining properties may be further enhanced by chilling the shaped product as it leaves the extruder or by moving it through a channel of refrigerated air.

Depending upon the recipe and the extrusion conditions being utilized, the resulting extruded composition may require an additional operation in order to be put into its finale edible form of a fluffy, crisp, light-textured food product. As previously noted, however, this final cooking operation may be conducted at the extruder die immediately

after the exposure of the mixture to the simultaneous action of heat, pressure and mixing. Thus, if the pressure-cooked product is not cooled upon approaching the extruder die but is, rather, maintained at the high cooking temperature which is encountered in the first section of the extruder, i.e. 200° to 350°F., there will be a "flashing off", i.e. a release of steam from the product as it emerges from the extruder die and passes into a region of ambient temperatures and pressures. The latter release of steam thus serves to reduce the moisture content of the product as well as to puff, i.e. expand, crisp and color it.

On the other hand, an extruded product which emerges from a cooled extruder die may be put into edible form by being deep-fried. In this operation the product is immersed in an edible cooking oil such, for example, as cottonseed, corn, coconut, soy or any mixture of the latter oils, and may be cooked for a period of 1/2 to 5 minutes at a temperature in the range of from 300° to 400°F. The precise combination of time and temperature which are utilized for the deep frying operation will, of course, depend upon the particular product which is being prepared as well as the oil being utilized.

In addition, the uncooked products resulting from a typical extrusion procedure, i.e. a procedure where flashing off is not utilized, may be subjected to other cooking techniques, such, for example, as baking, which serve to reduce the moisture content of the products as well as to convert them into fluffy, crisp, light textured, tasty, ready-to-eat food products.

It is to be noted that the food products of this invention can only be adequately described by making reference to the process which has been utilized for their preparation.

The following examples will further illustrate the embodiment of the invention. In these examples, all parts given are by weight unless otherwise noted.

EXAMPLE I

This example illustrates the preparation of a typical ready-to-eat, amylopectin-based food product of this invention by means of an extrusion process.

A dry mix comprising:

(1) 377 parts of waxy maize starch which had been crosslinked with 0.06%, by weight, of epichlorohydrin,

(2) 37.5 parts of a high amylose corn starch which contained 55%, by weight, amylose,

(3) 15.5 parts of vegetable shortening, and

(4) 5 parts of a glycerol monostearate emulsifier were thoroughly blended, in dry form, after which 65 parts of water were added thereto, whereupon the blending operation was continued until a homogeneous mixture was obtained. The resulting homogeneous mixture was then pumped into an extruder having a

barrel length of 25 inches and a conveying screw with a diameter of 1 1/4 inch which rotated at a speed of 125 r.p.m. The barrel temperature of the extruder was maintained at 290 to 300°F. while it applied a pressure of from about 50 to 300 psig. The cooked material was then passed from the heated barrel into a cooled barrel consisting of a water cooled cylinder in which a 3/4 inch conveying screw moved the material in contact with the cold cylinder walls through a shaping die. The temperature of the material as it passed through the shaping die was about 200°F.

The solid, rope-like food product which emerged from the die exhibited excellent shape retention properties as evidenced by the fact that it could, at this point, be readily cut into thin, shape-retaining slices. Immediately after cutting, and without an interim drying period, the thus cut slices were deep fried in corn oil which was at a temperature of 375°F. for a period of 30 seconds. The resulting fried products, which were now ready for human consumption, were found to be exceedingly crisp, light-textured and tasty.

EXAMPLE II

This example illustrates additional varieties of farinaceous base materials and formulations which can be effectively utilized in preparing food products by means of the process of this invention.

The procedure set forth in Example I, hereinabove was utilized using the formulations described hereinbelow:

Formulation A		parts
Waxy maize starch		710
Corn starch crosslinked with 0.14%, by weight of epichlorohydrin		124
Butter		31
Onion powder		5
Glyceryl monostearate		5
Water		130
Formulation B		parts
Waxy maize starch which had been inhibited and acetylated with 4.6%, by weight, of a 1:50 mixture of adipic acid and acetic anhydride according to the process set forth in U.S. Patent 2,935,510		597
Tapioca starch		240
Lard		31
Dried cheese powder		10
Pizza flavor		2
Salt		5
Glyceryl monostearate		5
Water		130

In each instance, the products resulting from the extrusion step exhibited excellent

shape-retaining characteristics as evidenced by the fact that they could be readily cut into slices immediately upon emerging from the extruder. The resulting slices derived from each formulation were deep fried in corn oil which was at a temperature of 375°F. for a period of about 30 seconds. The fried products thus produced were found to be exceedingly crisp and tasty.

EXAMPLE III

This example illustrates the preparation of a typical ready-to-eat, amylopectin-based food product which, in this case, was entirely devoid of any amylose.

The procedure set forth in Example I, hereinabove, was utilized using the following formulation:

Waxy maize starch which had been inhibited and acylated with 4.6%, by weight, of a 1:50 mixture of adipic acid and acetic anhydride according to the process set forth in U.S. Patent 2,935,510	parts	80
Corn oil		844
Glyceryl monostearate		41
Water		5
		110

The resulting food product exhibited excellent shape retention characteristics as evidenced by the fact that it could readily be cut immediately after extrusion. The resulting slices were immediately deep fried for a period of about 30 seconds in corn oil which was at a temperature of about 375°F. yielding fried products which were crisp, light-textured, and tasty.

EXAMPLE IV

The procedure set forth in Example I, hereinabove, was utilized using the following formulation with the exception that the product resulting from the extrusion step was cut into thin slices and dried so as to have a moisture content of 14% prior to being deep fried in corn oil, which was at a temperature of 375°F., for a period of about 30 seconds.

Waxy maize starch crosslinked with 0.04%, by weight, of epichlorohydrin	parts	110
Corn starch crosslinked with 0.14% by weight, of epichlorohydrin		253
Lard		54
Glyceryl monostearate		12
Water		1
		80

The fried products thus produced were found to be exceedingly crisp, light-textured, and tasty.

WHAT WE CLAIM IS:—

1. A process for the preparation of a food product which comprises the steps of:
 - (1) moistening a composition comprising an amylopectin product (as hereinbefore defined), said composition containing less than 5% by weight of amylose;
 - (2) subjecting the moistened composition to simultaneous heat, pressure and mixing action in order to effect the gelatinization and hydration of said amylopectin product;
 - (3) shaping the moistened composition which results from step 2; and
 - (4) cooking the moistened composition and thereby obtaining an edible product characterized by its light-texture and crispiness; said cooking procedure being conducted at a point in time simultaneous with or subsequent to step 3.
2. The process of claim 1, wherein said composition comprises an amylopectin product which, prior to the application of step 1 or 2, is blended with an additive selected from fillers, amylose containing materials, and mixtures of fillers and amylose containing materials; said fillers, if present, being present in a concentration no higher than 50% of the total weight of the solids of the moistened composition and said amylose containing materials, if present, being present in a concentration such that the amylose content of the composition is less than 5% of the total weight of the solids of the moistened composition.
3. The process of claim 1 or 2, wherein said composition is moistened with from 5 to 20% of water based on the total weight of the resulting moistened composition.
4. The process of any of claims 1 to 3, wherein said moistened composition is subjected, in step 2, to a temperature from 200°F. to 350°F. and thereafter, subjected to a temperature of from 100°F. to 212°F. while the pressure to which said moistened composition is subjected, in step 2, is in the range of from 10 to 5000 pounds per square inch gauge.
5. The process of any of claims 1 to 4, wherein step 4 occurs subsequent to step 3 and is conducted in a hot edible cooking oil.
6. The process of any of claims 1 to 5, wherein said amylopectin product is a waxy maize starch which has been inhibited with 0.4%, by weight, of epichlorohydrin.
7. The process of any of claims 1 to 3 and 6, wherein the pressure and the temperature to which said moistened composition is subjected in both steps 2 and 3 are maintained in the range of from 10 to 5000 psig and from 200°F. to 350°F., respectively, the maintenance of said moistened composition at the elevated temperature during step 3 thereby effecting the release of steam from said moistened composition upon the completion of step 3 simultaneous with the passage of the resulting shaped mass into a region of ambient temperature and pressure; the release of steam thus rendering the final product substantially crisp and light-textured.
8. The process of any of claims 1 to 7, wherein steps 2 and 3 are carried out in an extruder and step 4 is conducted at a point in time simultaneous with or subsequent to the expulsion of said edible product from the die of said extruder.
9. The process of claim 8, wherein said moistened composition is subjected, in step 2, to a temperature from 200°F. to 350°F. and thereafter, subjected in the extruder die, to a temperature from 100° to 212°F. while the pressure to which said moistened composition is subjected, in both the barrel and the die of said extruder, is in the range from 10 to 5000 pounds per square inch gauge.
10. The process of any of claims 1 to 3, 6, 8 and 9 wherein step 4 is carried out directly subsequent to step 3.
11. The process of any of claims 1 to 10 wherein the mentioned composition contains from 50 to 92% by weight of amylopectin based on the total weight of the moistened composition.
12. A process for the preparation of an amylopectin-based food product substantially as herein described.
13. A process for the preparation of an amylopectin-based food product substantially as described in any of Examples I to IV.
14. The amylopectin-based food product resulting from the process of any of claims 1 to 12.

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